It was shown that the pinning force in one dimensional case can be handled in a deterministic way, but the solution of the actual non-linear differential equations leads to a chaotic behaviour of the pinning-vortex interaction. This method provides the concept of the correlation length. The correlation length was determined with computer simulation and it is shown that there is sharp transition from linear to chaotic behaviour.

The large loss-free currents observed in type II superconductors are due to pinning of the vortices caused by inhomogeneities of the material. The Lorentz force exerted on the vortices by the current is balanced by pinning forces up to a critical current density $J_c$, where depinning occurs and the vortices start to drift and to dissipate energy. The sum of the elementary pinning forces to an average force density is the volume pinning force $J_c B$, where $B$ is the magnetic induction. The pinning problem in type II superconductors is basically a 3-dimensional effect, nevertheless to investigate the fundamental features of it the 1-dimensional modelling also provides some useful informations.

The generally accepted assumptions about the flux line lattice and pinning centres are as follows [1]

1. Non-interacting defects;
2. One defect in the interaction range of the flux line;
3. The defects are in randomly distributed positions;
4. The vortex lattice can be treated as an elastic continuum;
5. Thermal activation is negligible.

The pinning problem in type II superconductors averaging with randomly spaced weak pinnings generally is handled as a deterministic system in the sense that their differential equation defining the position of the individual flux lines is as follows [2]

$$c \frac{r_{i+1} + r_{i-1} - 2r_i}{\frac{1}{2}(r_{i+1} - r_{i-1})^2} = f_p(r_i, R_k),$$

where $c$ is the elastic constant, $r_i$ is the position of the $i$th vortex, $R_k$ is the position of the $k$th pinning centre and $f_p$ is the pinning force acting on the $i$th flux line.
where $a_1 = r_{i+1} - r_i$, is the lattice constant and

$$x_i^k = \frac{r_i - R_k + a_1/2}{a_1}. \tag{3}$$

By the help of this equation /1/ can be written in the form

$$\delta \left( \frac{1}{a_1} \right) = \frac{1}{c} \int \int \int \int f_p(\{x_i^k\}), \tag{4}$$

which shows that a change in the lattice constant occurs due to the existence of the pinning forces.

The other possible definition is as follows.

We should like to calculate the correlation length in case of 1-d collective pinning. There are at least two different methods yielding different correlation lengths.

One is the 1-d version of Larkin-Ovchinnikov approach [2], i.e. the regions of the vortex lattice in which relative shifts are less than the lattice constant will be called correlated regions. The linear dimension $L_c$ of correlated regions is determined

$$\left\langle \left| U(L_c) - U(0) \right|^2 \right\rangle = a^2 \tag{5}$$

where a is the displacement vector, $L_o$ is the correlation length.

The positional uncertainty of the $i$-th vortex

$$\Delta x_i = \Delta x_o + \int (1-j) \frac{1}{c} \frac{df_p}{dx} \Delta x_j, \tag{6}$$

where $f_p$ is the individual pinning force length.

Calculating the average response due to the displacement of the first vortex:

$$(\Delta x_i)^2 = (\Delta x_o)^2 + \int (1-j)^2 \frac{(df_p)^2}{c} \frac{dx}{dx} (\Delta x_j)^2. \tag{7}$$

From this we have [3]

$$L_c \sim L_p^{1/3} \cdot K^{-2/3}, \tag{8}$$

where

$$K \sim f_p/c \tag{9}$$